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Do preoperative hemoglobin and hematocrit levels predict postoperative nausea and vomiting in orthognathic surgery patients? A retrospective case-control study

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Abstract

Aim: Postoperative nausea and vomiting (PONV) is a common and distressing complication following orthognathic surgery. This retrospective study aimed to investigate the relationship between hemoglobin (Hgb) and hematocrit (HCT) levels and PONV occurrence in orthognathic surgery patients.

Material and Methods: A total of 52 patients who underwent orthognathic surgery were included in this retrospective analysis. Patients were divided into two groups: 26 patients who experienced PONV and 26 patients who did not. Demographic and clinical characteristics, including age, sex, American Society of Anesthesiologists (ASA) class, body mass index (BMI), operation time, and visual analog scale (VAS) scores for pain were compared between the groups. Hemoglobin and hematocrit levels were also compared, and receiver operating characteristic (ROC) analysis was performed to identify the optimal cut-off values for PONV prediction.

Results: No significant differences in age, sex, ASA class, or operation time were observed between the two groups. However, patients in the PONV group had significantly lower Hgb (12.9 ± 1.0 g/dL) and HCT (39.1 ± 3.0%) levels compared to those in the non-PONV group (14.2 ± 1.5 g/dL and 43.05 ± 3.5%, respectively; $p < 0.001$). The ROC analysis revealed that the optimal cut-off values for PONV prediction were Hgb ≤ 13.3 g/dL (AUC = 0.778, sensitivity = 73.08%, specificity = 69.23%, $p < 0.001$) and HCT ≤ 39.3% (AUC = 0.808, sensitivity = 65.38%, specificity = 88.46%, $p < 0.001$).

Discussion: Lower preoperative Hgb and HCT levels were significantly associated with the occurrence of PONV in orthognathic surgery patients. These findings suggest that Hgb and HCT levels may be useful predictive factors for PONV and can potentially assist in developing targeted preventive strategies to improve patient outcomes.

Keywords

Hematocrit, Hemoglobin, Orthognathic Surgery, Postoperative Nausea And Vomiting

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Introduction

Postoperative nausea and vomiting (PONV) are common and distressing complications that occur following orthognathic surgery, with reported incidence rates ranging from 30% to 80% [1,2]. PONV can negatively affect patient comfort, prolong hospital stays, and increase healthcare costs [3]. Identifying patients at risk for PONV can facilitate the implementation of appropriate prophylactic measures and improve patient outcomes.

Several risk factors for PONV have been identified, including patient-related factors (e.g., female gender, history of motion sickness), anesthetic factors (e.g., volatile anesthetics, nitrous oxide), and surgical factors (e.g., duration of surgery, type of surgery) [4]. However, there is limited research on the relationship between preoperative hematological parameters and the incidence of PONV, particularly in patients undergoing orthognathic surgery.

Although PONV is a well-studied postoperative complication, its relationship with preoperative hematological parameters, specifically hemoglobin (Hgb) and hematocrit (HCT) levels, needs to be better established. Anemia, generally associated with low levels of Hgb and HCT, has been linked with an increased risk of postoperative complications [5,6]. However, data specifically associating these parameters with PONV are sparse. Hemoglobin and hematocrit levels primarily determine the oxygen-carrying capacity in the body, and their decreased levels are often associated with hypoxia, which could potentially influence the risk of PONV [7,8]. However, the exact mechanisms of how this influence occurs have yet to be entirely understood and warrant further investigation.

While several studies have indicated an association between anemia and general postoperative complications, more attention needs to be paid to PONV[9-10]. Given the scarcity of research specifically examining the relationship between Hgb, HCT, and PONV, especially in the context of orthognathic surgery, this study aimed to address this gap in the literature and provide new insights into potential predictors of PONV.

Also, Hgb and HCT levels have been shown to influence blood viscosity, which may affect cerebral blood flow and perfusion in the area postrema, the brain's vomiting center [11]. As Hgb and HCT levels influence blood viscosity and potentially affect cerebral blood flow and perfusion in the area postrema, understanding their association with PONV is crucial.

Our study was guided by the following hypothesis - patients undergoing orthognathic surgery with lower preoperative hemoglobin and hematocrit levels may be more likely to experience postoperative nausea and vomiting than those with higher levels. This relationship could serve as a predictive tool for identifying patients at an increased risk of postoperative nausea and vomiting, thus guiding the implementation of preventive strategies.

Thus, this retrospective study investigated the association between preoperative Hgb and HCT levels and the occurrence of PONV in patients undergoing orthognathic surgery.

Material and Methods

In this retrospective study, we examined the medical records of a total of 52 patients who underwent surgery at our institution between January 2020 and December 2021. The study was conducted following approval from the Ethics Committee of the University's Faculty of Medicine, with ethical approval number 2023/366. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The inclusion criteria were adult patients (≥18 years) who had undergone elective surgery under general anesthesia. Exclusion criteria were patients with missing data, those with a history of motion sickness or PONV, and patients with chronic medical conditions that could affect the study results.

Intravenous 5-hydroxytryptamine (HT)-3 antagonist ondansetron was routinely administered to all orthognathic surgery patients, including those in this study, for PONV prophylaxis. The patients included 26 individuals who experienced PONV and another 26 individuals who did not experience PONV.

The study's main objective was to investigate the relationship between PONV and various demographic and clinical factors, including hemoglobin Hgb and HCT levels. Nurses identified and recorded instances of PONV, defined as active vomiting, retching, or nausea followed by vomiting, in the patient's medical records within the first 24 hours postoperatively.

Demographic and clinical data, including age, sex, American Society of Anesthesiologists (ASA) class, body mass index (BMI), operation time, and Hgb and HCT levels, were collected from the medical records.

Statistical Analysis

We used descriptive statistics to present the data in this investigation. Continuous variables exhibiting normal distribution were expressed as the mean ± standard deviation. We reported the median and minimum-maximum values for those not following a normal distribution. Categorical variables were presented as numbers and percentages. The normal distribution of numerical variables was assessed through the Shapiro-Wilk, Kolmogorov-Smirnov, and Anderson-Darling tests. To analyze differences between categorical variables in 2x2 tables, we used the Pearson Chi-Square and Fisher's Exact tests. For RxC tables, we utilized the Fisher-Freeman Halton test.

When comparing two independent groups for numerical variables exhibiting a normal distribution, we applied the Independent Samples t-test. For variables not following a normal distribution, we employed the Mann-Whitney U test for comparisons between independent groups.

To evaluate the predictive power of Hgb and HCT levels in relation to PONV, we conducted a Receiver Operating Characteristic (ROC) analysis. We computed the area under the curve (AUC), sensitivity, specificity, and cut-off values for both Hgb and HCT levels.

Statistical analysis was carried out using Jamovi (Version 2.3.24.0) and JASP (Version 0.17.1). A significance level (p-value) of 0.05 was set for all statistical tests. Power analysis was performed considering the effect sizes suggested by Cohen and using parameters consistent with similar studies in the literature [12]. For our specific study parameters, particularly the differences in preoperative hemoglobin (Hgb) levels between the two groups, the effect size was computed using Cohen's d formula, yielding a value of 0.95 [(14.2 - 12.9) / sqrt((1.5^2 + 1.0^2) / 2)]. Following a post hoc power analysis, and setting an alpha level (Type I error rate) at 5%, it was determined that

a sample size of 25 in each group (total of 50 individuals) was required to achieve a statistical power of approximately 95%. Therefore, based on our power analysis, the sample size in our study was considered adequate to detect the estimated effect size with a 5% Type I error rate.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

In the study, the demographic and clinical characteristics of all patients were assessed. The average age of the patients was found to be 21.2 years, with a majority of 67.3% being female and 32.6% being male. Most patients (92.3%) belonged to ASA class 1, while only 7.7% belonged to ASA class 2. The average operation time was determined as 264.3 minutes and the average BMI value was 22.4 kg/m2. The average Hgb value of all patients was 13.5 g/dL, and the average HCT value was 41.2% (Table 1).

Table 1. Demographic and clinical characteristics of the study patients

	Overall (n=52)
Age (year) §	21.2 [20.3 – 22.1]
Sex ‡	
Female	35 (67.3)
Male	17 (32.6)
ASA class ‡	
1	48 (92.3)
2	4 (7.7)
Operation time (min) §	264.3 [249.5 – 279.1]
BMI (kg/m^2) †	22.4 ± 2.8
Hgb (g/dL) †	13.5 ±1.4
HCT (%) †	41.2 ±3.9
PONV ‡	26 (50.0)

‡: n (%), †: mean ± standard deviation, §: median [min-max]; ASA: the American Society of Anesthesiologists, BMI: body mass index, PONV: postoperative nausea and vomiting, VAS: visual analog scale

Table 2 . Comparison of the patients with and without PONV in terms of the demographic and clinical characteristics.

	PONV		p
	Yes (n=26)	No (n=26)	
Age (year) §	21.3 [19.8 – 22.8]	21.1 [19.8 – 22.3]	0.804*
Sex ‡			
Female	18 (51.4)	17 (48.5)	0.768**
Male	8 (47.0)	9 (52.9)	
ASA class ‡			
1	23 (88.4)	25(96.1)	0.676**
2	3 (11.5)	1 (3.8)	
BMI (kg/m^2) †	23.3 ± 2.5	21.5 ± 2.8	0.021***
Operation time (min) §	255.0 [180.0 – 360.0]	270.0 [180.0 – 400.0]	0.652*
Hgb (g/dL) †	12.9 ±1.0	14.2 ±1.5	<0.001***
HCT (%) †	39.1 ± 3.0	43.05 ± 3.5	<0.001***

‡: n (%), †: mean ± standard deviation, §: median [min-max]; ASA: the American Society of Anesthesiologists, BMI: body mass index, PONV: postoperative nausea and vomiting, VAS: visual analog scale.; *. Mann-Whitney U test.; **. Pearson Chi-Square, or Fisher's Exact test. ***. Independent Samples T-Test.

Table 3 . ROC Analysis for PONV Prediction: Cut-off Values for Hgb and HCT

Prediction Model	AUC	Sensitivity	Specificity	Cut Off	95% CI	p-value
Hgb	Z.778	73.08	69.23	≤ 13.30	0.600- 0.852	<0.001
HCT	0.808	65.38	88.46	≤ 39.30	0.685- 0.904	<0.001

Abbreviations: AUC, Area Under the Curve; CI, confidence interval.

In the comparison of patients with and without PONV, there were no significant differences in age (p=0.804), sex (p=0.768), ASA class (p=0.676), and operation time (p=0.652) (Table 2). However, the BMI was significantly higher in the PONV group (23.3 ± 2.5) compared to the non-PONV group (21.5 ± 2.8) (p=0.021). Both Hgb and HCT levels were significantly lower in the PONV group (12.9 ±1.0 g/dL and 39.1 ± 3.0%, respectively) compared to the non-PONV group (14.2 ±1.5 g/dL and 43.05 ± 3.5%, respectively) (p<0.001 for both) (Table 2).

To predict PONV, ROC analysis was performed to determine the cut-off values for Hgb and HCT (Table 3). The cut-off value for Hgb was determined to be ≤ 13.30 g/dL, with an AUC of 0.778, sensitivity of 73.08%, and specificity of 69.23% (95% CI: 0.600-0.852, p<0.001). The cut-off value for HCT was found to be ≤ 39.30%, with an AUC of 0.808, sensitivity of 65.38%, and specificity of 88.46% (95% CI: 0.685-0.904, p<0.001).

Discussion

This study examined the associations between PONV and demographic as well as clinical data that included age, sex, ASA class, BMI, operation time, and Hgb and HCT levels. These data were meticulously collected from the patients' medical records. Our investigation revealed that a higher BMI and lower Hgb and HCT levels significantly contributed to the occurrence of PONV in patients.

Previous studies have reported associations between PONV and demographic and clinical factors. For instance, Apfel et al. conducted a large-scale study involving over 2500 patients. They identified female gender, a history of PONV or motion sickness, non-smoking status, and the use of postoperative opioids as significant risk factors for PONV [13]. Our study found a significant association between higher BMI and an increased risk of PONV. This finding aligns with numerous other studies in the literature. Qiu et al. conducted a retrospective study on same-day surgery patients and identified BMI as a predictor of PONV [14]. Similarly, Stephenson et al. observed a reduction in PONV after implementing preoperative risk stratification and adherence to a standardized antiemetic prophylaxis protocol, further supporting the association between higher BMI and PONV [15].

In contrast to our study, several other investigations have identified a significant relationship between lower BMI and the occurrence of PONV. For instance, Apipan et al. reported an association between PONV and lower BMI in patients undergoing oral and maxillofacial surgery [16]. Similarly, Silva et al. found a link between lower BMI and PONV in a retrospective study of patients who had orthognathic surgery [17]. Nitahara

et al. observed an association between lower BMI and the risk of nausea and vomiting in adult patients following vitrectomy [18]. Furthermore, Kranke et al. demonstrated in a systematic review that an increased BMI does not pose a risk factor for PONV [19], while Kim et al. conducted a propensity analysis revealing the impact of BMI on postoperative nausea and vomiting [20].

While there are studies in the literature investigating the relationship between platelet count, mean platelet volume, neutrophil-to-lymphocyte ratio (NLR), and PONV, no studies specifically exploring the association between Hgb, HCT, and PONV were found. Our study contributes to this knowledge gap by examining the potential relationship between these hematological parameters and PONV. We found that lower Hgb and HCT levels were significantly associated with PONV. One possible explanation for this association could be the impact of Hgb and HCT on blood viscosity and oxygen-carrying capacity [21]. Lower Hgb and HCT levels may lead to reduced oxygen-carrying capacity and decreased tissue oxygenation. Similarly, lower HCT levels could result in decreased blood viscosity, which may contribute to PONV by reducing blood flow and oxygen delivery to the brain [22]. This situation could potentially trigger PONV. It is important to note that our patient population did not include any anemic patients. In elective orthognathic surgeries, preoperative examinations include an assessment for anemia. If anemia is detected, appropriate consultations are made, and treatment is initiated. Surgery is then scheduled at a suitable time following the completion of the necessary treatment for anemia.

Despite the absence of anemic patients in our study, evaluating the relationship between Hgb and HCT parameters and PONV and determining cut-off values could provide valuable guidance in effective PONV prevention. By considering these cut-off values, healthcare professionals may be better equipped to identify patients at risk for PONV and take appropriate measures to prevent its occurrence.

Limitations

Our study has some limitations that should be acknowledged. Firstly, the limited sample size may restrict the broad applicability of the conclusions drawn. Secondly, the study's retrospective nature may introduce selection bias and limit the ability to establish a causal relationship between the variables. Lastly, as this research was conducted at a single institution, the generalizability of its findings to other contexts or demographic groups might be constrained.

Conclusion

The present study demonstrated that lower preoperative Hgb and HCT levels, as well as higher BMI, were significantly associated with PONV in patients undergoing orthognathic surgery. We also determined cut-off values for Hgb (≤ 13.30 g/dL) and HCT (≤ 39.30%), which may aid healthcare professionals in identifying patients at a higher risk of PONV. By considering these cut-off values, appropriate prophylactic measures can be implemented to improve patient outcomes. Further investigations involving multicenter studies and larger sample sizes are necessary to validate and strengthen the conclusions derived from our research, and to explore the potential underlying mechanisms linking Hgb, HCT, and PONV. Additionally, future research should investigate the role of other preoperative hematological parameters and their association with PONV.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

The authors declare no conflict of interest.

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